4. U.S. Crude Oil Imports: Growing U.S. Dependence

U.S. petroleum import dependency has almost doubled since the mid-1980's, to 8.4 million barrels a day. Crude oil import dependency has risen even faster. By 1996, crude oil accounted for nearly 90 percent of net imports, and U.S. refiners were running over 1 million barrels a day more imported than domestic crude. This chapter examines the decade of growth in U.S. crude oil imports, and describes the role that factors such as the regional shifts in the U.S. and world supply/demand balances, the expanded capability of the U.S. refinery complex, and environmental legislation have played in changing the quality and sources of these imports.

Introduction

Total U.S. imports of crude oil and petroleum products have increased dramatically since the mid-1980's, reaching a record 9.4 million barrels a day last year and accounting for over half the oil used domestically. Petroleum exports also increased over the same period, but only modestly. Thus, net U.S. petroleum import dependency has risen sharply, to 8.4 million barrels a day, and cost the U.S. nearly $60 billion last year. Both the country's thirst for and dependence on imports are still growing.

The majority of the imports – but the minority of exports – are crude oil. The U.S. has been a net importer of crude for almost half a century, but it was not until 1994 that it imported more than it produced. Since then, the gap has widened to almost 1.0 million barrels per day. Also since then, exports of Alaskan North Slope crude have been liberalized.

This chapter looks at how crude oil imports have evolved over the last ten years, focusing not only on what has driven the volume growth but also on the role that crude quality, regional shifts in U.S. and global supply/demand balances, and environmental legislation have played in the changing mix of crude sources. It also considers some of the economic, logistical, and political implications of these changes. While the focus of this chapter is therefore on crude oil (rather than products) and on imports (rather than exports), the discussion must begin with a broader view of the import-export picture to provide the necessary context for understanding the relative role of crude oil imports.

U.S. Total Oil Imports

The record 9.4 million barrels per day of crude oil and petroleum products imported by the U.S. last year keep it firmly at the top of the world importer rankings (Figure 50). In the mid-80's, the U.S. was only importing 5.0 million barrels per day, barely half of today's level. But the trend has not always been up. Gross imports had reached 8.8 millions of barrels per day back in 1977, before collapsing over the following six years. Because of the substantial growth in exports, net imports (imports minus exports) just failed to set a new record in 1996, averaging 70 thousand barrels a day less than in 1977.

Imports Driven by Increasing Demand and Declining Production

U.S. gross import dependency has fluctuated broadly in line with the fluctuations in import volumes. It reached a peak of 48 percent back in 1977, dropped to 32-35 percent between 1982 and 1985, and then picked up fairly steadily to reach 52 percent last year. While this was a new record, it was not the first time the politically sensitive 50 percent level had been exceeded. That also happened in both 1993 and 1994. Net imports dependency reached 46 percent of demand, nearly equaling the 1977 record.

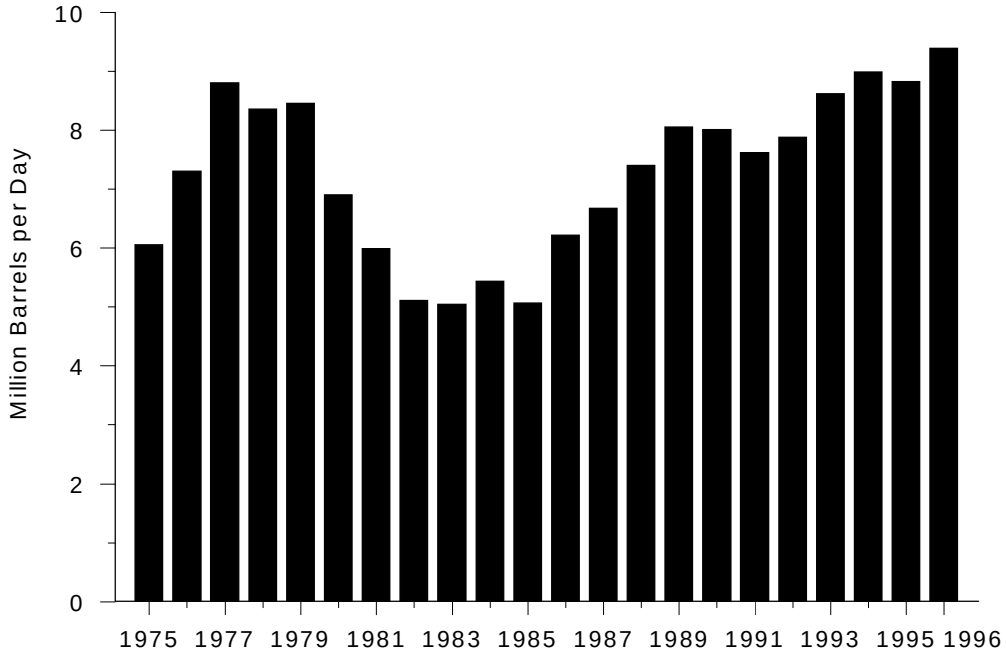
Net imports fill the gap between U.S. demand for oil and the country's capability to produce it. These swings in import levels are therefore driven by the relative swings in U.S. supply and demand.

U.S. Demand: Approaching Its Late 1970's Record High

Demand is the more variable of the two factors (Figure 51). It reached its all-time high of 18.8 million barrels per day almost 20 years ago, in 1978. By the early 1980's, it had plunged to 15.2 million barrels per day, but by last year, it had rebounded to 18.2 million barrels per day. This represents an increase of 3.0 million barrels per day, or 20 percent, over the mid-1980's low point, and a new peak in this current growth phase.

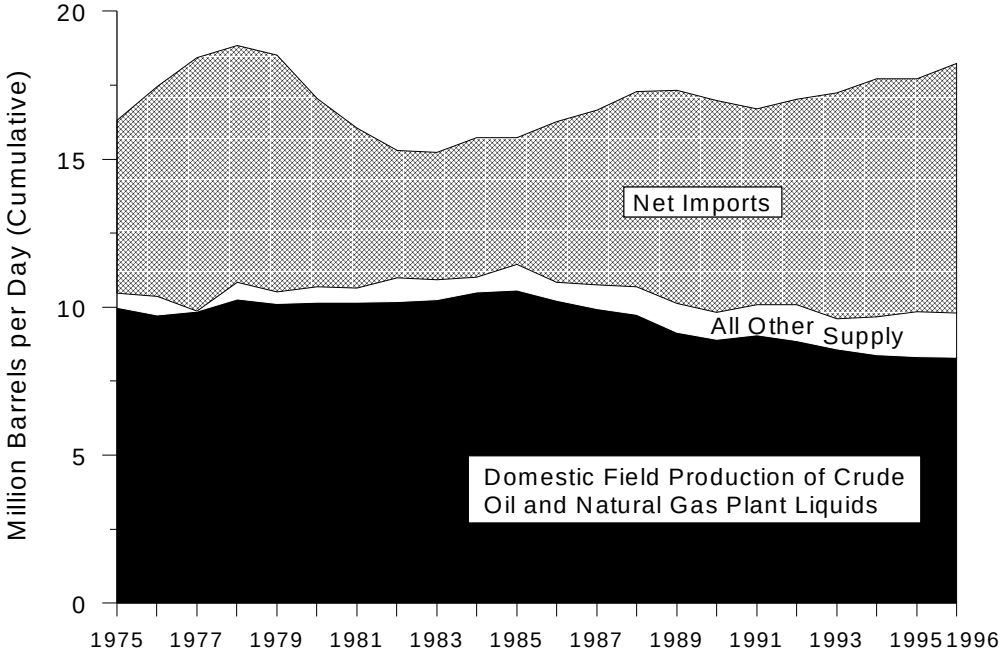
The primary driver for these oil demand swings over the last 20 years has been the level of economic activity, which is itself, in part, a function of oil prices. Each of the last three

Figure 50. U.S. Gross Oil Imports, 1975-1995



Sources: **1975-1980:** Energy Information Administration (EIA), *Petroleum Supply Monthly* (February 1993), Table S3. **1981 Forward:** EIA, *Petroleum Supply Monthly* (February 1997), Table S3.

Figure 51. U.S. Petroleum Supply and Demand



Note: All Other Supply includes refinery processing gain, unaccounted for crude, stock change, and field production of other hydrocarbons.
Sources: **1975-1980:** Energy Information Administration (EIA), *Petroleum Supply Monthly* (February 1993), Table S1. **1981 Forward:** EIA, *Petroleum Supply Monthly* (February 1997), Table S1.

U.S. recessions (1974-75, 1980, and 1991) was immediately preceded by a sharp increase in the price of oil that, in the latter two cases, was subsequently eroded. Oil use stumbled as economic activity dipped, and then subsequently recovered as the economy picked up speed again. Each time, the recovery in demand for oil was only partial, resulting in a steady loss of market share to other fuels that was not reversed until quite recently. These earlier losses and the current gain can be understood by dividing markets for oil into two categories — captive and multi-fuel — according to their vulnerability to substitution.

In the early 1980's, after two oil price shocks and fears of more to come, and after the decontrol of domestic oil prices, newly attractive alternatives like coal and nuclear were not just gaining a major share of the new multi-fuel markets, like power generation, but were also rapidly displacing oil from many of the existing multi-fuel markets. This further amplified the demand losses triggered by the 1980-82 recession. Gradually, this displacement pendulum lost momentum. With the capital investment made and with low operating costs, coal and nuclear could not easily be dislodged from their newly won markets, even when oil prices fell. But they have been making few new inroads. The trickle of ongoing gains has been centered on natural gas.

Captive markets are not immune to economic and price signals. However, devoid of ready alternatives, the oil demand elasticity of such markets is necessarily limited. For a period in the 70's and 80's, price signals and the introduction of more efficient vehicles significantly influenced the transportation sector (passenger cars, trucks, planes, trains, and buses) which currently accounts for over two-thirds of total consumption. This further contributed to the sharp downturn in oil demand in the early 1980's. But prices and price expectations receded, and many of the older less efficient vehicles have been replaced. Growth in the captive markets has reemerged, as can be illustrated by looking at gasoline, and there are no longer significant losses in the multi-fuel markets to mask it.

The CAFE (Corporate Average Fuel Efficiency) standards institutionalized fuel efficiency improvements for on-highway vehicles, helping reduce gasoline demand from a peak of nearly 7.2 million barrels per day in 1977 to 6.3-6.4 in the first half of the 1980's. But the momentum was not maintained. Today, Americans own more vehicles than ever, and with a greater proportion than ever being gas-guzzling sport utility vehicles and mini-vans. Since, headlines to the contrary, gasoline is cheap — 1996's average pump price, adjusted for inflation, was one of the lowest of the post-war period, and only about one-third of the price in Europe — Americans are also driving their vehicles further and faster. Gasoline demand therefore recovered to a new record high of 7.6 million barrels per day last year, 40 percent of total oil demand.

U.S. Supply: Gradual Decline from Its Early 1970's Peak

U.S. production of crude oil and natural gas plant liquids has been declining since the early 1970's from its 11.3 million barrel-per-day peak, despite temporary relief provided by the 1977 start-up of Alaskan North Slope production (centered on Prudhoe Bay, the largest field ever found in the U.S., with 12 billion barrels of recoverable reserves). The decline has occurred mainly because the U.S. is the most mature producing region in the world, with over three million oil and gas wells completed since the first was drilled in Pennsylvania in 1859. Given the declining resource base, domestic oil resources are in constant need of exploration and development to sustain production (see Chapter 3). Yet the U.S. has steadily been de-emphasized by many companies, as the rest of the world has opened up to upstream activity, providing more attractive investment opportunities.

However, with production still averaging 8.3 million barrels per day, the U.S. remains a world leader, second only to Saudi Arabia. With the breakup of the Soviet Union, Russia has dropped to third, and is struggling to stay within 2.0 million barrels per day of the U.S. level.

Oil production, which covers crude oil, condensate, and natural gas liquids, accounts for the vast majority (85 percent) of the 9.8 million barrels per day of domestic supply. The rest comes from a variety of sources, the most important of which is *processing gain*, the volume gain that occurs at refineries as crude is processed into a stream of products that have, on average, lower densities. The more complex the refining system is, i.e. the greater the proportion of light products it is able to make, the greater the processing gain. The U.S., with the largest and most complex refining system in the world, achieves a processing gain of 800 thousand barrels per day, which is over 8 percent of all domestic supply. Synthetic hydrocarbons, such as ethanol or MTBE, are another supply source, averaging 300 thousand barrels per day.

In total, these non-production sources of domestic supply averaged over 1.5 million barrels per day last year, more than three times their level in the mid-70's and mid-80's. Without this contribution, the decline in domestic supply and the growth in imports over the last decade would have been even more dramatic.

Outlook For Imports: More Growth, More Records

Now that substitution losses are offsetting so little of the growth in the captive markets, U.S. demand is moving back up toward its record high. By 1998, the EIA forecasts it will reach 18.6 million barrels per day, 0.4 million barrels per day higher than last year, and only 0.2 million barrels per day below the 1978 record.

Over the next couple of years, the non-production sources of supply are expected to grow more slowly, largely because there is now little regulatory incentive either to continue expanding oxygenate production or to upgrade aggressively (and thus boost processing gain). However, despite the growth in Gulf of Mexico flows, the decline in domestic production is expected to continue unchecked. Thus, the decline in total domestic supply will accelerate slightly, falling to 9.4 million barrels per day by 1998, the lowest level since 1965.

In the near term, with the expectation that consumption will continue to grow and that supply will continue to decline, there is only one direction for imports to go: up, to new record highs in terms of both volume and dependency. By 1998, EIA expects gross crude oil and petroleum product imports to breach the 10 million barrel a day level for the first time ever.

U.S. Import Dependency Is Modest in Global Terms

Figure 52 places the U.S. dependence on imports in a global context. Both world oil consumption and supply are displayed on a regional basis, with each region's "gap" indicating whether it is a net importer or exporter. To simplify, the U.S. has been combined with its two NAFTA partners, Canada and Mexico, to comprise North America (while also still being separately identifiable). These partners are two of the top oil suppliers to the U.S. The net import dependence for North America is therefore very much less than for the U.S. alone.

On a regional basis, North America is the number one consumer, as it has been for decades. Asia/Oceania has recently leapt into second place ahead of Europe, growing by 70 percent in ten years and even outstripping the U.S. in 1996. This alone would have pulled the center of gravity of world oil demand eastward, but this shift was given additional momentum by the unprecedented demand collapse in the Former Soviet Union (FSU). Demand there almost halved in the first half of the 1990's, falling by over 4 million barrels per day.

The picture for supply is in sharp contrast to that for consumption. North America is important, but the Middle East dominates the picture. The dominance would be even greater if the region's major producers were to use all their production capacity, as every other producer in the world does. Iraq cannot, because of the U.N. imposed embargo; a few others choose not to, limiting their production to their OPEC quota level instead. The Middle East's dominance has increased significantly over the last ten years, not only because production there has nearly doubled but also because of declines in both the U.S. and the Former Soviet Union (FSU). The latter is primarily one dramatic consequence of the delay in the FSU's attempted transition to a new political, economic, and social order. All the other regions have enjoyed growth, particularly those that have made the greatest efforts to attract private and foreign investment.

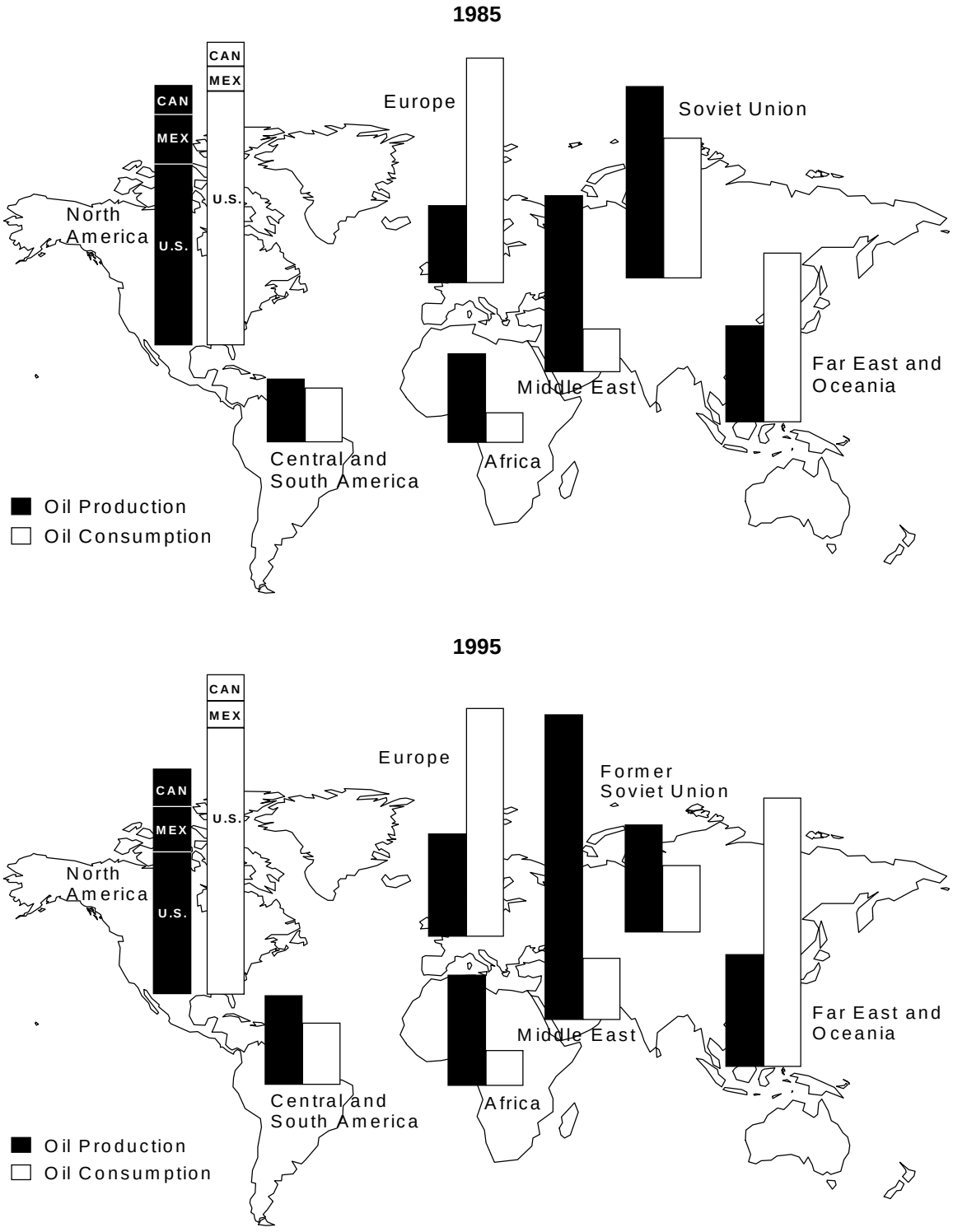
When the two parts of the regional balances are put together, it shows that all three main consuming regions are net oil importers, while all the major producing areas (except North America) are net exporters.

The honor of being the largest regional importer falls to Asia/Oceania. This region's net import requirement now exceeds over 10 million barrels per day, for an overall import dependency of over 60 percent. On both counts, it has greater import exposure than the U.S. However, the regional dependency is not really representative of any of the individual countries. A few, such as Indonesia, are net exporters; others, such as China, have just become net importers; most are almost totally import dependent. This latter group includes Japan, a very distant second to the U.S. in the rankings of consuming countries, using almost 6 million barrels per day.

Europe has the next highest need for imports. Unlike Asia/Oceania, its need has been declining, thanks to the tripling of Norway's production and, to a minor degree, Eastern Europe's demand collapse, and is now under 9 million barrels per day. But like Asia/Oceania, regional import dependency is an unrepresentative 60 percent. Most of Europe's production comes from the North Sea, shared between the U.K. and Norway. That leaves most European countries in a position similar to Japan's: almost entirely dependent on imports.

Thus, although U.S. oil imports are an important force in the world oil trade, they do not constitute an unprecedented regional flow. Also, U.S. oil import dependency is much less than that of most of its major allies, who tend to be less well endowed geologically.

Figure 52. Regional Supply and Demand Balance, 1985 and 1995



Notes: Oil production includes crude oil, natural gas plant liquids, other liquids, and refinery processing gains. Oil consumption includes internal consumption of all refined products, refinery fuel and loss, and bunkering.

Sources: **1985:** Energy Information Administration (EIA), *International Energy Annual 1986* (October 1987), pp. 30-31. **1995:** EIA, *International Energy Annual 1995* (December 1996), pp. 5-7 and 207-209.

Crude Oil Dominates U.S. Imports

The U.S. imports both crude oil and products. Crude oil has consistently dominated the flows (Figure 53). Last year, crude oil accounted for 80 percent of all U.S. oil imports, averaging 7.5 million barrels per day.

This preference for crude oil in part reflects history. The domestic refining industry has long-established roots because the U.S. was one of the pioneers of the modern oil era, with enough crude oil of its own to be a net exporter for the first one hundred of its one hundred and fifty years as a producer. It also reflects the basic economics of the industry worldwide: it is generally more cost-effective to refine products close to the point of consumption. This is confirmed by the composition of world trade in petroleum: 80 percent by volume is crude (and the share is even larger in ton-mile terms). Governments also often intervene in the market to swing the economics even more in favor of domestic refining, justifying it as enhancing supply security.

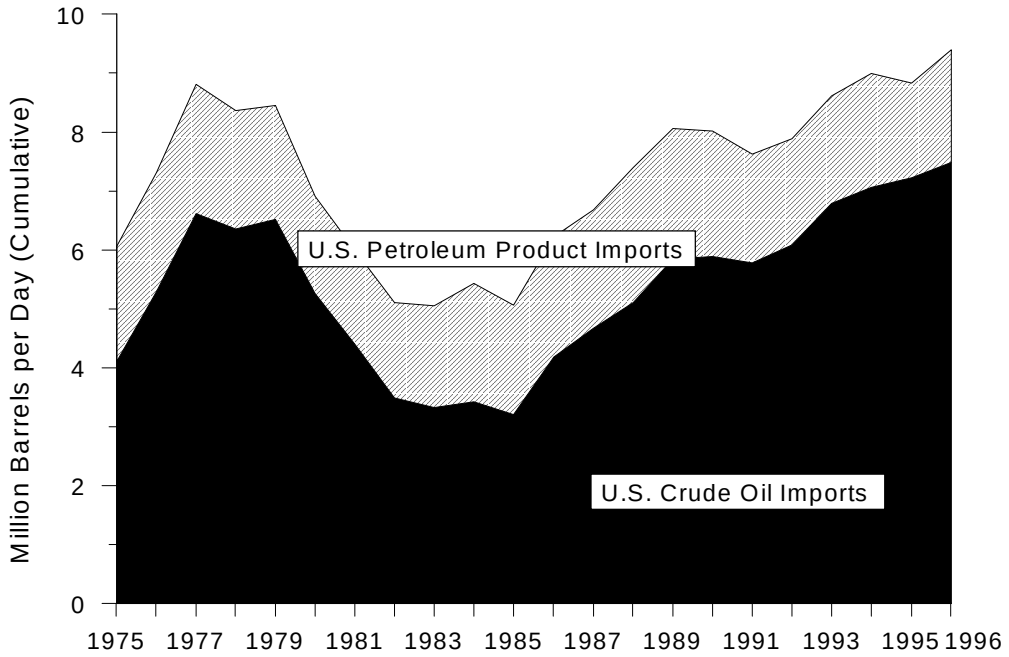
The growth of crude imports over the last decade sharply underscores the incentive for U.S. refiners to maximize runs, particular since there have been no new, "grassroots" refineries built in the Lower-48 during this period. Runs were raised through a combination of refinery restarts, expansions, debottlenecking, and improved operating practices such as extending the time between turnarounds.

Product imports primarily play a balancing role in world oil markets, with their flows varying depending on factors like weather, refinery turnarounds, or accidents. They can also be the consequence of local resistance to refineries. The U.S. East Coast provides one of the clearest examples of this. It refines only one-third of the products it consumes. To fill the gap, it takes products from other regions while also importing three-quarters of all the finished products coming to the U.S.

As would be expected from the foregoing, crude has borne the brunt of the swings in U.S. imports over the last twenty years, but its share has never dropped below 60 percent. Between the mid-1980's low in total imports and last year, total crude oil imports increased by over 4.0 million barrels per day while product imports increased by less than 100 thousand barrels. Ranges better capture the volatility of imports, particularly of products. Even so, they show product flows varying between 1.6 and 2.3 million barrels per day during the last twenty years, while crude varied between 3.2 and 7.5 million. Crude's variability has been six times that of products.

Some of the main characteristics of product imports are highlighted in the box on p. 71. The rest of this chapter concentrates on crude oil.

Figure 53. Crude Oil Dominates U.S. Imports

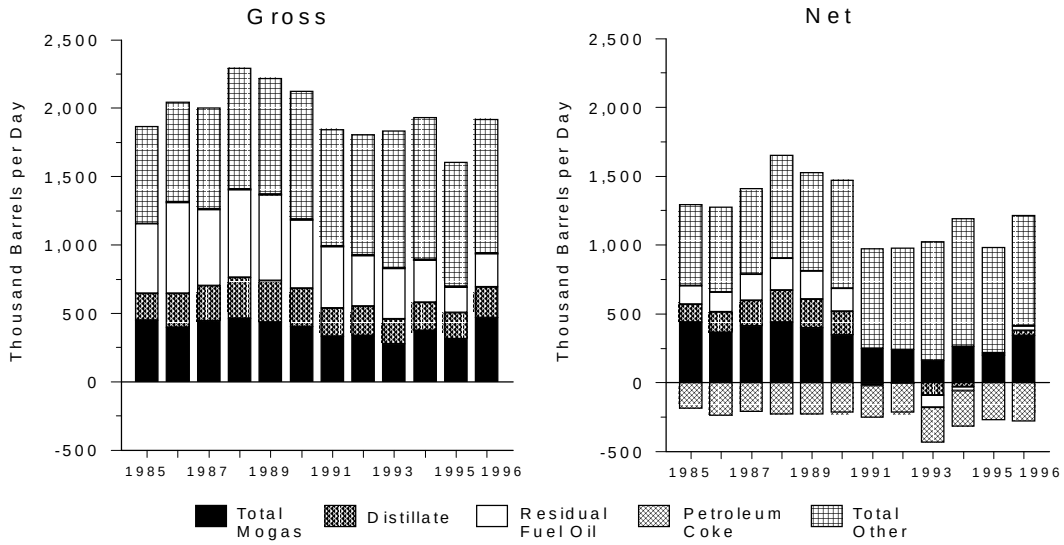


Sources: **1975-1980:** Energy Information Administration (EIA), *Petroleum Supply Monthly* (February 1993), Table S1. **1981 Forward:** EIA, *Petroleum Supply Monthly* (February 1997), Table S1.

Product Imports

Product imports have followed a very different trend from crude imports in the last decade. They rose to a peak of 2.3 million barrels per day in the late 1980's as U.S. refiners struggled to keep up with the rapid growth in oil consumption, particularly of light products. They then slipped back, undermined first by the 1990/91 recession and then by the surge in refinery upgrading capacity that resulted largely from the requirements for cleaner fuels in the Clean Air Act Amendments (1990) and other environmental legislation. Aided also by steadily increasing refinery utilization rates and by the growth in production of synthetic hydrocarbons, like MTBE, domestic production has met a growing percentage of U.S. oil demand. The low point for product imports was reached in 1995, when imports dipped to 1.6 million barrels per day, undermined by the fierce inter-fuel competition that drove residual fuel oil demand to a post World War II low. In 1996, product imports recovered to 1.9 million barrels per day, in line with 1991-1994, but only slightly higher than 1985's level.

U.S. Gross and Net Product Imports, 1985-1996



Over the same period, product exports took another step up. Until the early 1980's, they consisted primarily of petroleum coke, since most other products were tightly regulated. As export license requirements were eliminated, exports started to grow. Light product exports received a particularly strong boost after Iraq's destruction of Kuwait's refining capacity in 1990 led to a significant shortfall of products into Asia, just as oil demand there started to soar. U.S. exports of both gasoline and distillate doubled. Even though Kuwait's capacity has been fully restored, the higher export levels have been sustained. Having had a crash lesson in how to export such products successfully, and having experienced no political backlash, U.S. refiners and marketers now move their surpluses to whichever overseas market is most attractive at a particular time. Thus, distillate exports to western Europe averaged less than 5 thousand barrels per day during the first eight months of 1996, but jumped to about 80 thousand barrels per day in the final four, when the trans-Atlantic arbitrage window was wide open.

As a consequence of these two disparate trends, net product imports in 1995 were less than half their 1988 peak of 1.6 million barrels per day. Net imports have declined for all main products, but most notably for distillate where, in a break with the past, the U.S. has been theoretically self-sufficient in distillate since 1991, i.e. net imports have been approximately zero. The overall downtrend was reversed in 1996 when, aided by the exceptionally cold 1995-1996 winter and by the European gasoline glut, net product imports jumped back up over 1 million barrels per day. Capital investment in the refining sector is expected to slow, now there is a lull in environmentally-driven, mandated investment, leaving domestic refiners unable to keep pace with the expected growth in consumption. Thus, further increases in net product imports are expected over at least the next few years.

The reduction in net imports has been another negative for the U.S. refining sector because it has undermined margins. Price in an importing region is the balancing market price plus transportation. In an exporting region, it is that price minus transportation. As imports shrink, their balancing, or price-setting, market moves closer; as exports grow, theirs moves further away. In each case, this reduces the relative price in the price-taking market. This is what has been happening in U.S. main product markets over the last few years. For example, in the late 1980's, imports of distillate reached about 300 thousand barrels per day, and came from a wide variety of sources. Now, imports have dropped by about a third, to around 200 thousand barrels per day, with 90-95 percent coming from just three nearby locations: E. Canada, the Virgin Islands, and Venezuela. Simultaneously, exports have doubled, also to around 200 thousand barrels per day, with a significant proportion of Gulf Coast volumes having to go as far as Asia. Consequently, both Gulf coast and East Coast distillate prices are lower relative to the world market, and to crude, than they would have been if there had been no change in product flows.

An Overview of Crude Oil Imports

Imports of crude oil have grown dramatically since the mid-1980's, when domestic crude production began its most recent decline phase. Crude oil now accounts for over 80 percent of total petroleum imports.

Imports Have Set Four Consecutive Record Highs...

U.S. gross crude oil imports averaged 7.5 million barrels per day last year, the fourth consecutive record high (Figure 54), and the third consecutive year that they have exceeded domestic crude production. This puts crude imports more than 1.0 million barrels per day above the prior cycle's 1977 peak of 6.6 million, and 4.5 million above its 1985 low.

Back in the late 70's and early 80's, crude oil imports received a boost of about 150 thousand barrels per day from the building of the Strategic Petroleum Reserve (SPR). There have not been any imports for the SPR for nearly three years now. The government has recently started to sell limited volumes of SPR oil for both operational and fiscal reasons (see Chapter 5).

U.S. crude flows are not entirely one way. Exports occur, but are just a fraction of imports because they are largely precluded by highly restrictive regulations. Exports mainly consist of Alaskan North Slope crude delivered to U.S. possessions and territories, particularly the Virgin Islands. Because of these exports, U.S. net dependency on the global crude oil market has been 1-2 percent lower than its gross dependency.

... And Will Continue to Increase

Total U.S. imports will continue to grow in the near term, increasing by around 900 thousand barrels per day over the next two years. As in the past, most of this increase will be crude — over 80 percent for this period. Thus, the rate of growth of crude imports will be slower than over the last decade, but the average annual volume increment will be higher. Both gross and net crude oil imports will continue to set new record highs.

As domestic crude production continues to decline, more questions are being asked about the appropriateness of existing marker crudes[24] for the U.S., particularly inland ones like West Texas Intermediate (WTI). Will rising imports present new alternatives? Many imported crudes, like those from Saudi Arabia, Mexico, and Venezuela, are hamstrung by resale restrictions, so growth in their flows will not increase liquidity in the Gulf Coast crude market. Colombia's Cusiana crude seems a possibility on the face of it, with volumes expected to jump to 450 thousand barrels per day before the end of 1998, with the U.S. being its target market, and with the equity owners willing to trade. Cusiana's big drawback is the proven vulnerability of its export pipeline to guerrilla attacks and, therefore, repeated force majeure. The best alternative may lie even closer to home in the rapidly rising flows from the Gulf of Mexico, typified by the sour Mars Blend stream.

[24]A marker crude is one used as a basis for the pricing of other crudes.

Sources Of U.S. Crude Oil Imports

Economics drive the flow of crude oil — unless there are political constraints such as embargoes. A crude flows first to its most profitable market, the one that nets back the best value. Then, as volumes grow, it spreads out to steadily less profitable markets. Logistics are one of the prime determinants of such profitability rankings. Thus, crude tends to be sold to nearby, or short-haul, markets first, and then to progressively more distant, or medium- and long-haul, markets, other things being equal.

Short-haul Crudes Now Dominate

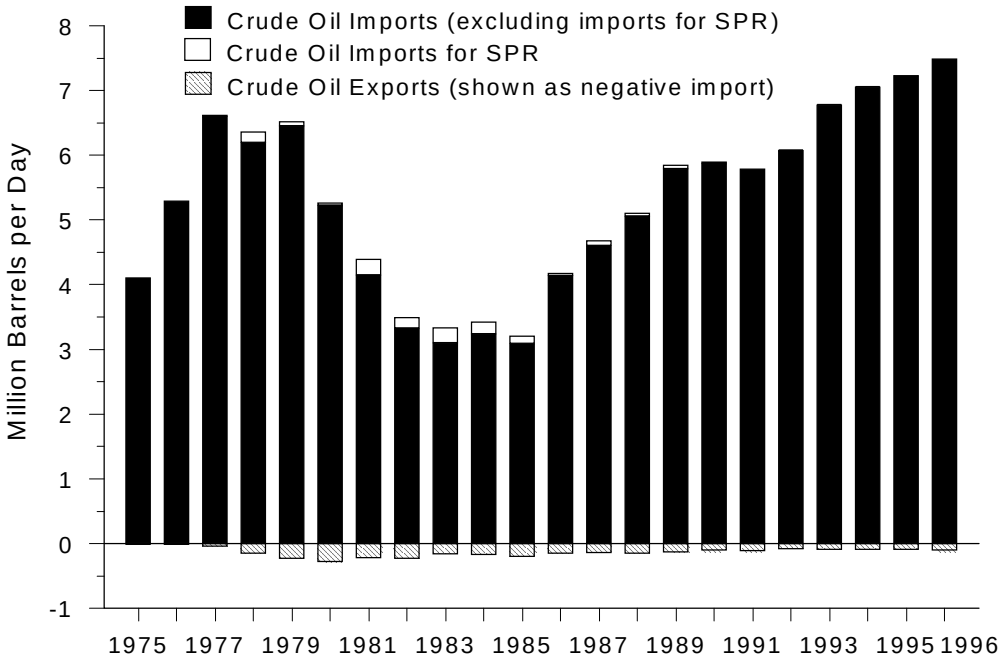
Figure 55 shows the main flows of crude into the U.S. in 1996, with the width of the arrows proportional to the annual volume on any given route. All these flows move by tanker, with the exception of Canadian imports, which move by pipeline.

Short-haul imports, defined here as those from Canada, Mexico, and Central and South America, clearly dominate, accounting for 4.0 million of the total 7.5 million barrels per day. This is the first time ever that the U.S. has obtained the majority of its crude from the Western Hemisphere.

The Crude Mix Used To Be Different

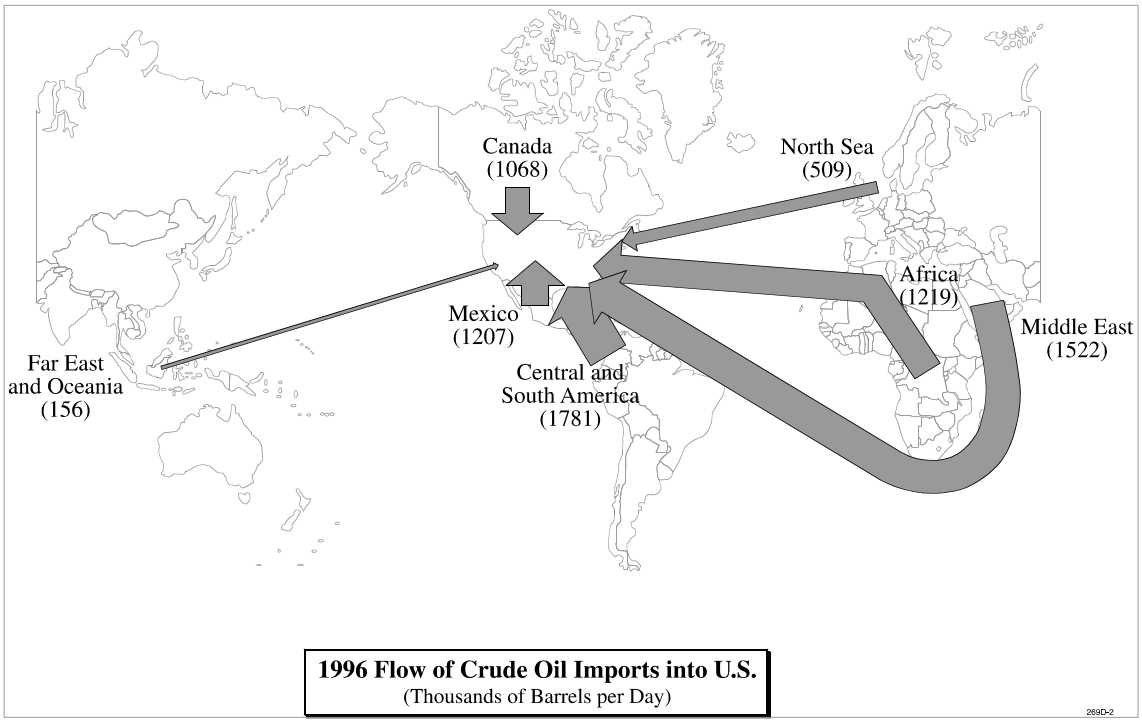
The mix of supply sources for U.S. crude oil imports has changed significantly as volumes have risen, shifting away from regions frequently cited as politically unstable (Figure 56). Some have concluded that this makes the U.S. less vulnerable to price shocks. It is important to understand, though, that it is not the degree of U.S. dependence that will determine the impact on price of any disruption in a

Figure 54. U.S. Crude Oil Imports: Net and Gross



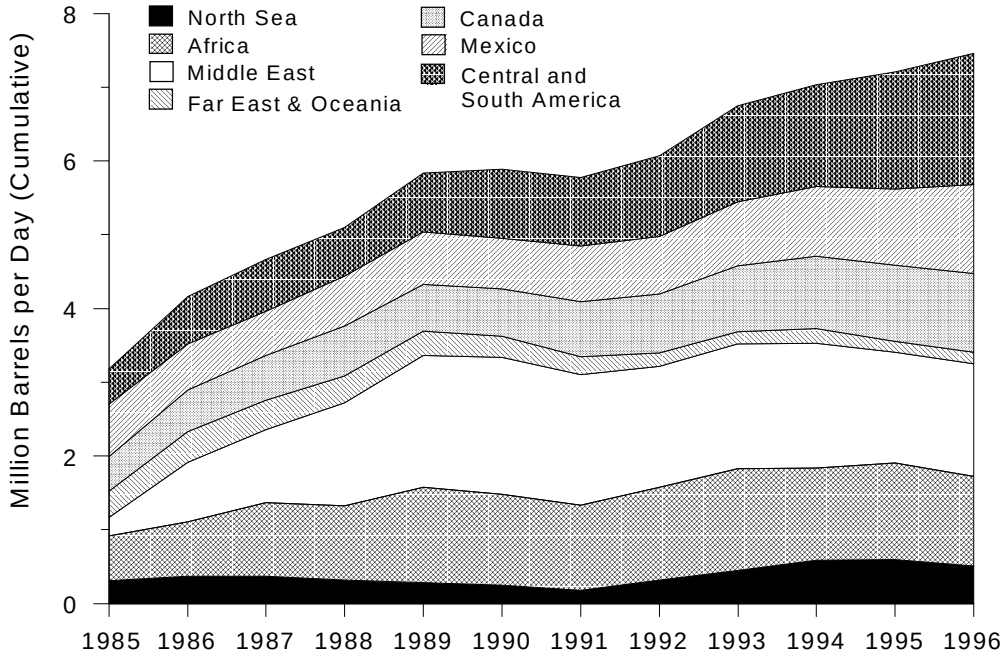
Sources: **1975-1980:** Energy Information Administration (EIA), *Petroleum Supply Monthly* (February 1993), Tables S1 and S2. **1981 Forward:** EIA, *Petroleum Supply Monthly* (February 1997), Tables S1 and S2.

Figure 55. Origin of U.S. Crude Oil Imports, 1996
(Thousands of Barrels per Day)



Source: Energy Information Administration (EIA), Form EIA-814 data.

Figure 56. Changing Regional Patterns for U.S. Crude Oil Imports



Source: Energy Information Administration (EIA), derived from Form EIA-814 data.

particular region. Rather, it is that region's role in the global market.

Only one major region supplies less to the U.S. than it did in the mid-80's: the Far East & Oceania. This reflects the increased refining flexibility that has made the West Coast less reliant on the high quality crudes that are characteristic of this regional source, together with the increased willingness of integrated companies to optimize their crude slates on a global basis, and not just within their own company systems.

One of the most significant developments in the 1990's has been the decline in importance of Middle East crudes to the U.S. market. They were the fastest growing import stream between 1985 and 1990, rising to account for nearly one-third of all U.S. crude oil imports. The consensus view was that this share would continue to grow. Not only has the share declined, to just 20 percent in 1996, but the absolute volume has declined too.

Politics have played a role in this. Since mid-1990, Iraqi exports have been subject to a near total global embargo, only partially lifted in December 1996. Also, the U.S. has maintained a unilateral embargo on Iranian crude that dates back to October 1987. These limit the possibilities for Middle East crudes coming to the U.S. But the role of politics in determining the crude mix should not be overemphasized. It has been subsidiary to the main issue, which is the establishment of a new paradigm for the upstream sector of the oil industry.

Thanks to the aggressive implementation of new technology, the radical restructuring of operating practices, and the almost universal opening up of the upstream,[25] the global crude oil supply curve has been shifted significantly to the right, i.e., the volume of crude that can be economically produced at a given price has risen. Hence, despite prices that have been lower than were expected from the viewpoint at the end of the 1980's, OPEC, and most particularly its Middle Eastern members, have been called on to produce much less in the 1990's than was then expected because production almost everywhere else has soared.

Therefore, the sources of short-haul crudes have enjoyed rising production that has left them able to increase exports, and their preferred target, logically, has been the U.S. Latin America has been the star performer, with imports to the U.S. growing by 1.4 million barrels per day since 1990. All the medium and long-haul exporters to the U.S. market have lost ground to some degree. It has been particularly hard for

[25]Opening up of the upstream refers to the broad-ranging political, economic, institutional, and contractual changes that have occurred in virtually every oil-producing nation making their oil resources increasingly accessible to world oil markets.

the Middle East to compete because its crude is of the same quality, heavy sour, as the majority of short-haul grades. The less voluminous, light, sweet, short-haul grades, such as Olmeca (Mexico) and Cusiana (Colombia), have been partly responsible for the North Sea and Africa's shrinking share of U.S. crude imports in the last few years.

These changes in the long-haul/short-haul mix of imported crudes tend to lower the volume of stocks held onshore in the U.S. Firstly, a just-in-time inventory strategy argues for lower stocks if a supply source is nearer – a somewhat specious argument, perhaps, if those suppliers are already producing at maximum, have no buffer stocks themselves, and have a history of interruptions. Secondly, parcel sizes for short-haul crudes are generally smaller than those for long-haul crudes, meaning more frequent deliveries and a lower average stock level (see Chapter 5).

Six Countries Supply 80 Percent of U.S. Crude Imports

Not all countries in a region are the same, at least from the standpoint of being crude suppliers to the U.S. market. U.S. import dependency is much more concentrated than the regional analysis might suggest (Table 5).

The U.S. gets almost two-thirds of its crude oil imports from just four countries, each of which supplied over 1.0 million barrels per day last year: Canada, Mexico, and Venezuela, all short-haul sources, and Saudi Arabia, a long-haul source. Adding in the next two in the rankings, Nigeria and the North Sea (really Norway and the UK, but generally counted together in oil supply terms), takes the proportion up to 80 percent. The remaining 20 percent is split between 32 other countries.

It is more than just physical closeness and geology that has made the three leading short-haul suppliers so dominant. Firstly, Canada has no viable export market other than the U.S. Secondly, both PDVSA, and, more recently, Pemex (respectively the Venezuelan and Mexican national oil companies) have shrewdly invested via joint ventures in increasing the complexity of U.S. refineries. By enlarging the nearby, higher valued market for their poor quality crudes — referred to as increasing their fungibility — Venezuela and Mexico have leveraged the value of large segments of their crude production.

There are several reasons why Saudi Arabia, alone among long-haul suppliers, has been able to remain a significant exporter to the U.S. market, including:

- sheer size — the world's largest importer and the world's largest exporter want to do business together;
- the historic links between Saudi Arabia and the ex-Aramco partners: Mobil, Chevron, Exxon, and Texaco (see also Figure 62);
- ongoing embargoes of two of its Middle East rivals, and
- its transformation into a short-haul source for many of its U.S. customers by using the Caribbean as a transshipment center, and selling FOB out of there.

This last strategy has two side benefits. Saudi Arabia benefits because it raises the netback value of its sales in a backwardated market, the prevailing condition of the last couple of years (see chapter on futures). Its customers benefit because Saudi Arabia is, in effect, now holding some of their operating stocks in the Caribbean, reducing their working capital needs and reducing onshore U.S. stocks in the process (see chapter on stocks).

Where In The U.S. Does the Imported Crude Oil Go?

Every region in the U.S. imports some crude oil, but the regional similarities tend to end there because the different regions have distinctly different crude oil needs and choices.

Crude Oil Import Dependency Varies Regionally

The U.S. regional crude oil supply/demand balances are far from homogeneous (Figure 57). At one extreme is the East Coast, the most supply deficient of all the regions, which refines much less than it consumes. It is also dependent on imports for almost all the crude it runs. At the other extreme is the Gulf Coast, with substantially more refinery capacity than needed to meet its own consumption. It is the country's swing refining region, sending its surplus to fill in deficits elsewhere, mainly on the East Coast and in the Midwest.

One of the few common threads between the regions is that, to a greater or lesser degree, they all import crude. The Gulf Coast imports the most, receiving 4.3 million barrels per day last year, almost 60 percent of the total. Next comes the Midwest, closely followed by the East Coast. Both take less than a third of the Gulf Coast volume.

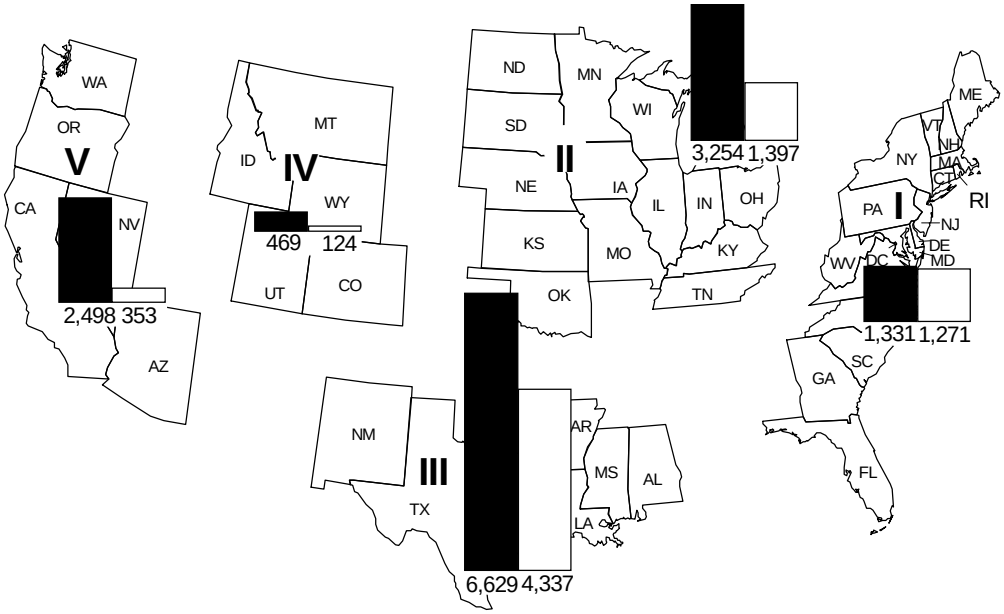
The Gulf Coast's role in crude oil imports is even larger than these data imply because, except for flows from Canada, all of the Midwest's imports move via the Gulf Coast, using the same ports and some of the same distribution infrastructure as the volumes that the Gulf Coast refines itself. Last year,

Table 5. The Top Six Sources of U.S. Crude Oil Imports, 1996
(Thousand Barrels per Day)

Year	Venezuela	Saudi Arabia	Mexico	Canada	Nigeria	North Sea	Rest of the World	Total
1985	306	132	715	468	280	309	991	3,201
1986	416	618	621	570	437	370	1,145	4,178
1987	488	642	602	608	529	374	1,432	4,674
1988	439	902	674	681	607	316	1,489	5,107
1989	495	1,116	716	630	800	278	1,808	5,843
1990	666	1,195	689	643	784	250	1,668	5,894
1991	668	1,703	759	743	683	180	1,044	5,782
1992	826	1,597	787	797	665	319	1,091	6,083
1993	1,010	1,282	863	900	722	449	1,561	6,787
1994	1,034	1,297	939	983	624	586	1,600	7,063
1995	1,151	1,260	1,027	1,040	621	599	1,533	7,230
1996	1,305	1,248	1,207	1,068	592	509	1,553	7,482

Source: Energy Information Administration, *Petroleum Supply Monthly* (February 1997), Table S3.

Figure 57. U.S. Regional Dependence on Crude Oil Imports, 1996



Source: Energy Information Administration (EIA), derived from Form EIA-814 data.

almost 600 thousand barrels per day of crude moved to the Midwest this way.

Crude Imports Have Shifted East and South Since the 1970's

The pressure the record high U.S. crude import level puts on different regions varies (Figure 58). Three regions still lag their prior peaks, all of which were set in the late 1970's. The West Coast has the most leeway; only importing one-third of its 1977 pre-Prudhoe Bay level of 1.1 million barrels per day last year. Declining production and rising throughput have pushed the Midwest to within sight of its 1977 peak, while the restart of Tosco's Trainer Refinery in Philadelphia in mid-1997 could be enough to take the East Coast to new highs. But it is PADD III, the Gulf Coast, and to a lesser degree PADD IV, the Rocky Mountains, that have already been presented with new challenges from record import flows.

Well before even the current levels of crude oil imports were reached in these two regions, concerns were being raised about the adequacy of both the ports and the pipeline systems to handle the flows. The reality has been that the infrastructure has shown an unprecedented degree of flexibility. Pipelines have been reversed (Mobil), debottlenecked (Arco), extended (Diamond Shamrock), built (Express), newly connected (Amoco), or even switched from natural gas to crude oil service (Seaway). While getting sufficient crude supply to the U.S. might at times be a legitimate concern, handling it once it reaches the U.S. should not be, barring accidents.

Quality Issues

Crudes are not all alike. They differ considerably in their physical properties, with the important differences being the proportions of the various hydrocarbon fractions that can be turned into the different products and the levels of various contaminants, such as sulfur or metals. These properties affect the ease with which refiners can process various crude oils into the different products required by consumers. The two physical properties that are most often quoted for crude oil are:

- API gravity, which is a measure of a crude oil's density or specific gravity. A high gravity crude is 'light' and a low gravity one is 'heavy'. Other things being equal, a light crude yields more light products than a heavy crude.
- Sulfur content, which measures a crude oil's sulfur by percent weight. A low sulfur crude is 'sweet', and a high sulfur one is 'sour'. Sulfur is a pollutant. Its level in finished products is increasingly being limited in the U.S., mostly by Clean Air Act regulations.

Crude Oil Values Vary Directly with Quality

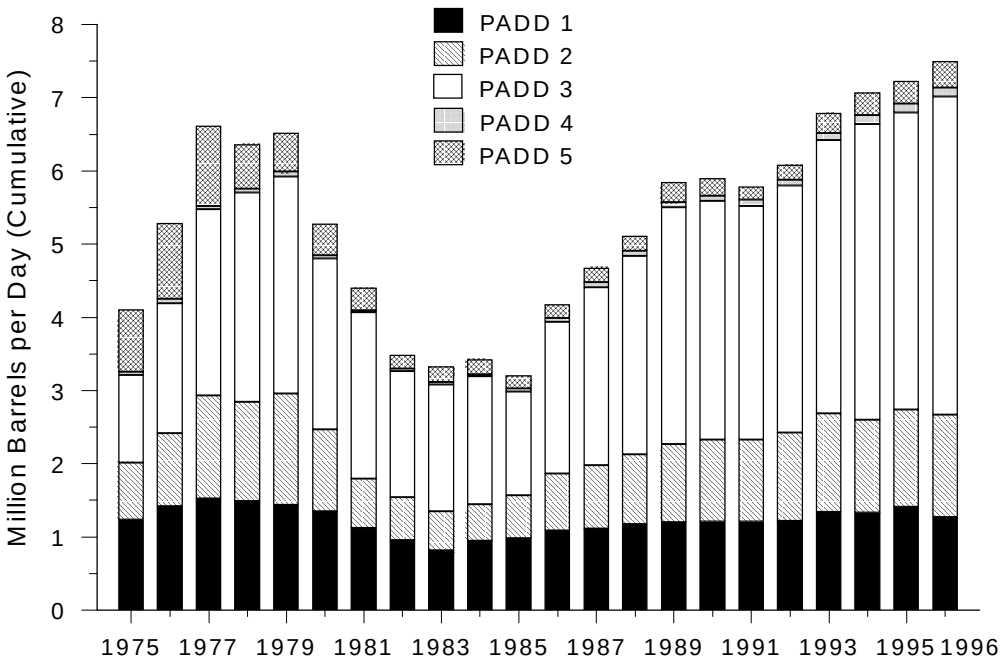
A refiner is interested in a crude for the value of the products it yields. His aim is to turn the crude into as much of the lighter, higher priced products and as little of the heavier, lower priced products as is cost-effectively possible. In the U.S. market, that usually means maximizing gasoline while minimizing the residual fuel oils and other residues that sell for less than the price of the crude.

Refineries, like crudes, differ. A simple refinery produces products that reflect the natural characteristics of the crude. As a refinery becomes more sophisticated, it produces more light ends and less residual oil, because the heavier materials are reprocessed into feedstocks for additional, and generally high capital investment, processing units.

The yield, or mix, of products a refiner produces therefore depends on his choice of crude and the operating configuration of his refinery. Thus, taking value as the aggregate revenue from the products produced from the crude less the cost of refining it, different crudes can have different values for the same refiner, while the same crude can have different values for different refiners. (Note: in choosing which crude to buy, a refiner would need to compare this value with the delivered cost of the crude to calculate its marginal value, and rank the results.) In general, light crudes are more valuable than heavy ones, and sweet crudes more valuable than sour. These quality differentials, or differences in value between light and heavy, and between sweet and sour crudes, vary between refiners, between regions, and over time (see Chapter 7).

Hence quality, like logistics, is a prime determinant of crude flows. The demand curve for a particular crude therefore varies as both the transportation cost and the quality differential vary, making the curve non-linear with respect to logistics. In other words, to progressively place a crude, a producer can be moving back and forth between closer and more distant markets, depending on the relative trade off between the cost of transportation and the quality premium for the crude in each market at that time. The resultant market clearing price will not necessarily be set either in the same market each time, or in the most distant market that takes the crude.

Figure 58. U.S. Regional Dependence on Crude Oil Imports Over Time, 1975-1996



Sources: **1975-1980:** Energy Information Administration (EIA), Energy Data Reports, Petroleum Statement Annual. **1981-1995:** EIA, *Petroleum Supply Annual* (February 1997), Table 34.

Imports Are Poorer In Quality Than Domestic Crudes

Refiners aim to find the most cost effective way to meet demand within the constraints of their own facilities. As the U.S. refining system is the most complex in the world, and as U.S. crude quality is better than the world average, it is hardly surprising that imported crudes lower the quality of the crude slate that U.S. refiners run (Figure 59). This deterioration is particularly pronounced for sulfur, with imports having double the unusually low level in domestic crudes.

The West Coast is the only region where imports do not reduce the quality of the crude slate. The quality of its own production is very much worse, at 24 degree API and 1.2 percent sulfur, than that in any other region in the U.S. It has therefore long imported crudes toward the high end of the quality spectrum, pulling its quality average closer to the U.S. norm. Historically, these crudes generally came from Asia, particularly Indonesia and Malaysia. Over time, the West Coast refiners upgraded, lessening their need for such extremely light sweet crudes. An increasingly large proportion of their imports then gradually shifted toward Alaskan North Slope 'look-alike' grades, to give themselves purchasing leverage in an oligopolistic market for a crude whose production was steadily declining.

On a simultaneous gravity and sulfur ranking, PADD III imports the worst crudes. A major influence here are the joint venture investments that heavy crude producers like Venezuela and Mexico have been successfully pursuing to improve the fungibility of their crudes in U.S. markets. Their main target has been the Gulf Coast.

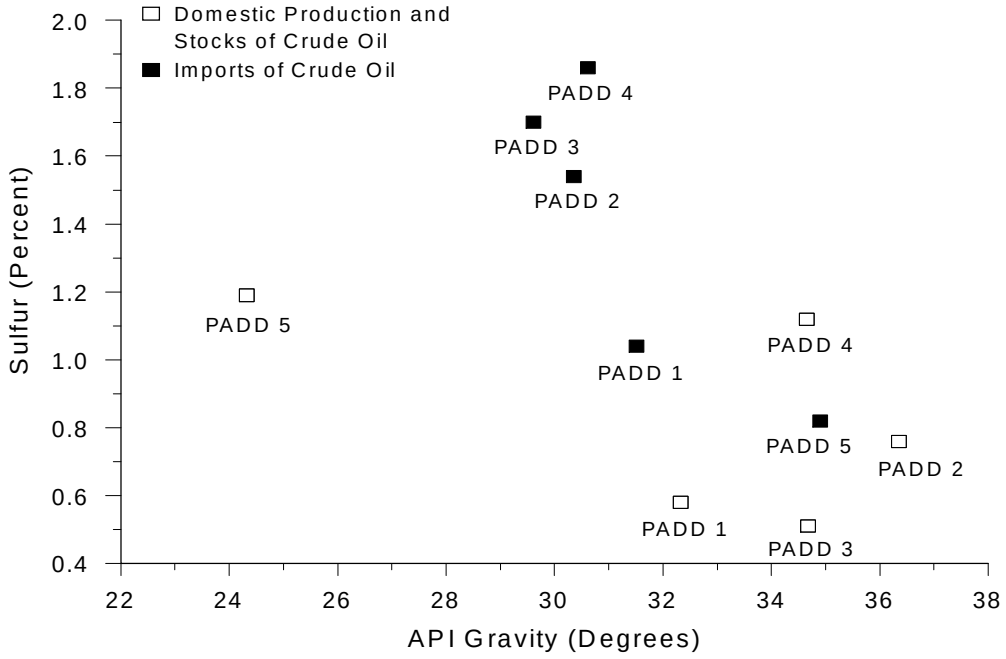
PADD IV, the Rocky Mountains, comes a surprisingly close second, considering it is a market dominated by smaller, niche refineries. Logistics make Western Canada its preferred — and, currently, its only nondomestic — crude supplier. As production there got heavier, the economic imperative to upgrade became overwhelming for the Rocky Mountain refiners accessing those crudes.

Different Regions Supply Different Quality Crudes

U.S. crude oil imports fall into two clear quality groups, sweet and sour (Figure 60). Canada, Mexico, Venezuela and Saudi Arabia supply the poorer quality, sour, predominantly heavy grades, while the North Sea, Africa, and the rest of Latin America supply the better quality, sweet, frequently light grades.

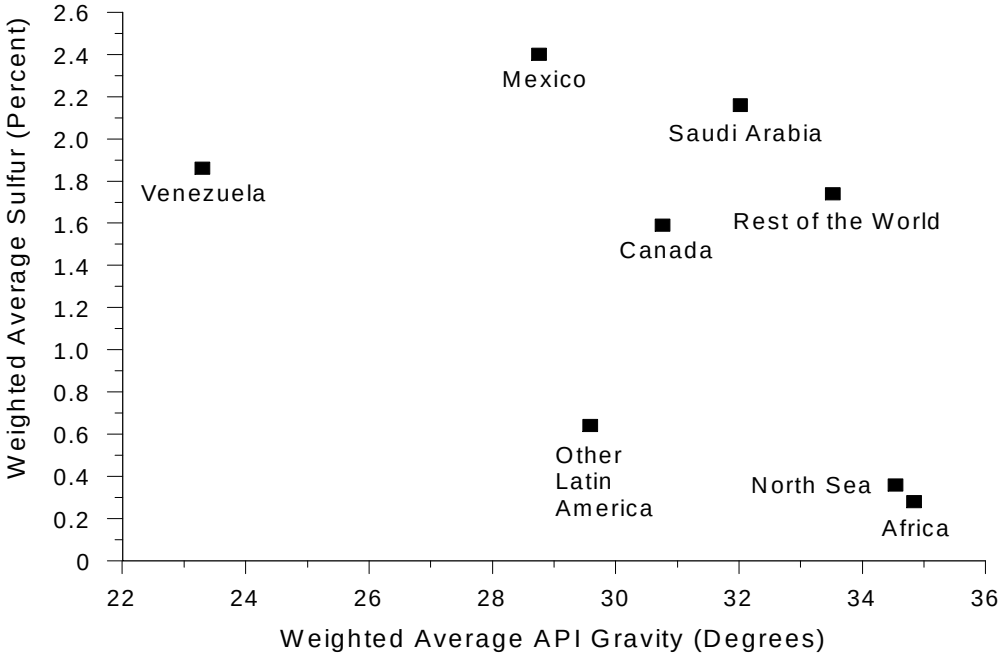
There is strong competition between suppliers within each of these two groups, with logistics generally being the deciding

Figure 59. A Comparison Between Imported and Domestic Crude Oil Quality in 1996



Sources: Energy Information Administration (EIA). **Imports:** derived from Form EIA-814 data. **Domestic:** derived from Forms EIA-810 and EIA-814 data.

Figure 60. The Quality of U.S. Crude Oil Imports by Supply Region, 1996



Source: Energy Information Administration (EIA). Form EIA-814, with imputed values for 1 to 4 percent of data.

factor between winners and losers. Saudi Arabia's competitive disadvantage in the sour group has already been noted. In the light sweet group, the competitive disadvantage, vis-a-vis the U.S. market, lies with the African producers, particularly West African countries like Nigeria and Angola. Of course, these countries have a competitive advantage over the North Sea vis-a-vis the Asian market. This has made them the swing source for the world light, sweet crude market, just as the Middle East is for the heavy, sour market. West African crudes are now routinely pulled or pushed between the Americas and the Far East, depending on the relative strengths of their respective markets. This competition is reflected in the price of Asian quality crudes relative to Brent, which depends on many factors, including the time of the year, accidents at refineries or oil fields, and the pace of tightening quality standards.

There is also competition between the quality groups. This influences, and is influenced by, the level of the quality differentials. This competition has contributed to the changing quality of U.S. imports over time.

The Quality of U.S. Imports Has Deteriorated

The quality of U.S. crude imports today is lower than it was in the mid-1980's, as is the quality of U.S. refinery runs as a whole (Figure 61). This is mainly the result of aggressive capital investment by the U.S. refining sector that has raised the complexity of the whole system and made it capable of running a higher proportion of poorer quality crudes despite a lightening of the mix of products being consumed and a tightening of product quality standards. But why did U.S. refiners choose to do this?

- The U.S. is the world's leading importer. Its refiners need flexibility if they are not to be held hostage by suppliers, particularly in the light of two trends that have long been expected to prevail: that U.S. imports will continue to grow, and that world crude quality will deteriorate (an expectation that has not always been fulfilled).

- U.S. demand is significantly more skewed to light products, especially gasoline, and away from residual fuel oil, than the norm elsewhere in the world. Refiners therefore have a relatively greater economic incentive to invest aggressively in residual destruction units.

- Environmental legislation, such as the 1990 Clean Air Act Amendments, effectively forced investment in upgrading. The marginal cost of adding upgrading capability beyond that required by cutting edge U.S. environmental restrictions has been frequently relatively low. Venezuela and Mexico actively sought joint venture upgrading investments in the U.S. market.

This upgrading allowed the short-haul suppliers to win an even larger share of the U.S. market, by allowing them to compete successfully with suppliers of light sweet crudes, like Africa. Thus the observed swing in the U.S. from medium and long-haul toward short-haul crudes was not purely the result of logistics.

Most of the deterioration in import quality had occurred by the early 1990's. The subsequent leveling off came about largely because the quality of the crude being produced worldwide improved, due to a major production shift by Saudi Arabia from its medium and heavy to its lighter grades, coupled with the geologic coincidence that the surge in non-OPEC production in the first half of the 1990's was biased toward light sweet crudes.

Crude Sources for the Largest Importers

Nine U.S. refining companies each imported more than 300 thousand barrels per day of crude last year, accounting for almost two-thirds of all U.S. crude imports. Leading the pack was Citgo, closely followed by Mobil and Texaco. Beyond size, the top nine's crude import slates had little in common (Figure 62).

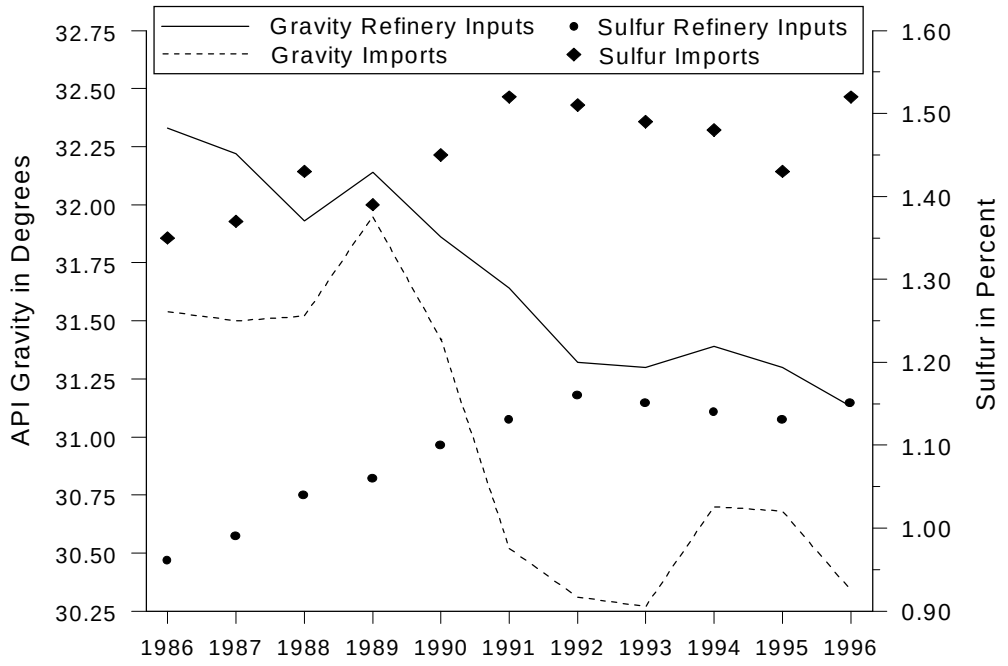
(Note: imports made by joint venture refining companies are combined with those of the U.S. based parent company most responsible for supply, i.e. Star with Texaco, Lyondell and Unoven with Citgo, the wholly-owned U.S. subsidiary of PDVSA, and Deer Park, a limited partnership of Pemex with Shell Oil, with Shell Oil.)

Many, frequently interdependent, factors contributed to this lack of homogeneity. The most obvious one is ownership/vertical integration through a joint venture relationship with a producer, because this resulted in importers that were especially single minded about their crude sources:

- *Citgo*: Last year, 85 percent of its crude imports were from Venezuela. Another 7 percent were from Mexico, indicating that Citgo was already capable of running an unusually heavy slate. This year, with Lyondell's new coker up and running, the proportion of heavy, Latin American crudes could move even higher.

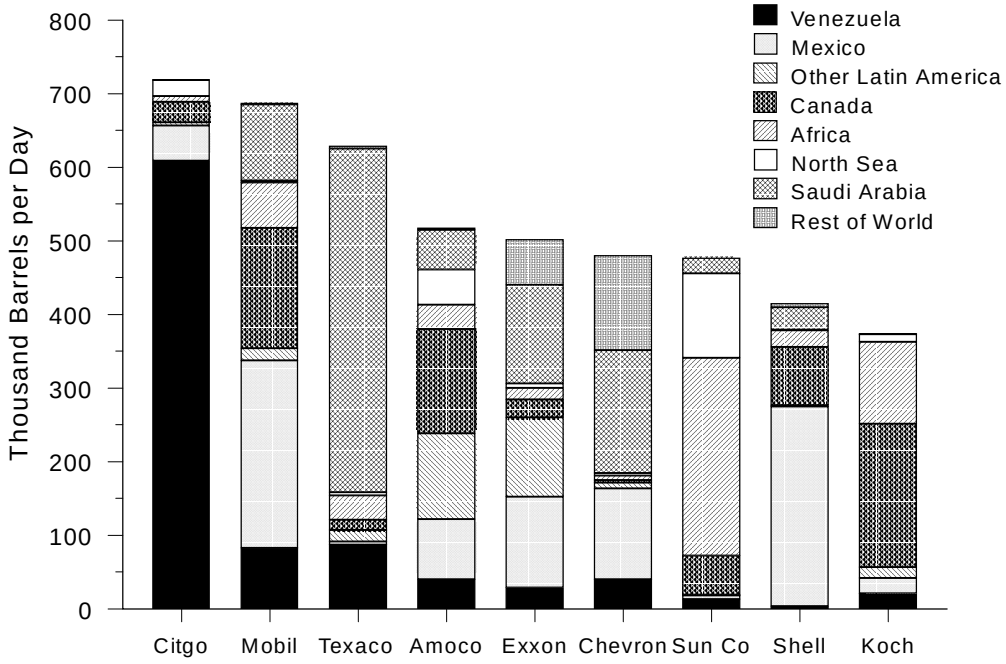
- *Texaco*: Its joint venture partner in Star is Saudi Arabia, which accounted for three quarters of Texaco's imports in 1996. Such a strong link with a long-haul supplier

Figure 61. Quality Trends in U.S. Crude Oil Imports and Refinery Inputs



Sources: **Import Data:** Energy Information Administration (EIA), derived from Form EIA-814. **Refinery Inputs:** EIA, *Petroleum Supply Annual* (1986-1995) and EIA, *Petroleum Supply Monthly* (March 1996-February 1997).

Figure 62. U.S. Crude Oil Imports by the Top Nine Importing Refiners and by Supply Region, 1996



Source: Energy Information Administration, Form EIA-814 data.

could be a competitive disadvantage in a U.S. market dominated by short-haul imports.

- *Shell Oil*: Its joint venture arrangement with Pemex at its Deer Park refinery included installation of a new coker. Last year, two thirds of its imports were from Mexico.

The others on the Top Nine list have more diverse crude import portfolios, but the factors driving many of the choices are still frequently easy to determine. These factors include:

- *Location* is why Koch Industries took half its crude from Canada. Its main refinery in Minnesota has gained significant competitive advantage from maximizing its use of Canadian Heavy, which has frequently traded in a buyer's market. Amoco and Mobil's propensity for Canadian crude has the same derivation.

- *Equity production* — either present or past — is why Amoco is the only significant importer of Trinidadian crude, and Chevron and Exxon are the largest importers from Saudi Arabia after Texaco/Star.

- *Refinery configuration constraints* mean Sun's slate is dominated by West African and North Sea crudes because its refineries are relatively simple by U.S. standards. Sun adopted a policy last year of minimizing capital investment, dropping out of the asphalt market, and restricting its crude slate to quality crudes.

Sun would probably have had the company of one other light sweet oriented importer on the Top Nine list if either British Petroleum had not sold its Marcus Hook, Pennsylvania, refinery to Tosco in February 1996, or Tosco had chosen to run it last year. But that would still place such importers in the distinct minority. If size is in any sense an indicator of success, then this analysis confirms a strong correlation between success and the ability to run significant proportions of poor quality, imported crudes.

The list of the largest crude importers has changed over time as mergers and acquisitions have reshaped the downstream sector. With a new wave of restructuring sweeping through the industry, further changes are inevitable. In particular, the top nine importers, whoever they are, will become even more dominant.

Seasonality of Imports

U.S. crude oil import requirements are seasonal (Figure 63), tied to, but not precisely in step with, the seasonality of U.S. oil consumption. Since imports are the marginal source of supply for the U.S. market, they can be thought of as an indicator of both refinery runs and consumption. Whether they lead or lag stock policy, and by how much, is a function of price, particularly the inter-month spreads, as well as other factors, such as refinery turnarounds, accidents, and supply disruptions (see Chapters 5 and 6).

In general, the volume of total and of the better quality, light sweet crude imports varies seasonally. U.S. consumption's summer peak is driven primarily by gasoline, as people take to the road during the traditional vacation season. This peak consumption coincides with the tightest seasonal quality specifications for gasoline, and presents a challenge to the U.S. refining sector, for which its upgrading capacity for the cheaper, poorer quality crudes is inadequate, even when fully utilized and with no turnarounds. Refiners turn for their marginal barrel to grades with a naturally high gasoline fraction, which means they turn to the light sweet crudes.

U.S. consumption is counter seasonal to global consumption, which is strongly winter peaking, with a 3-4 million barrel a day swing from quarterly peak to trough. These regional differences cause crude flows to swing west into the Atlantic Basin in the spring and summer, and east into the Pacific Basin in the winter. Such flows are accompanied by, if not initiated by, swings in relative crude prices. This causes the relative strength in U.S. domestic crude prices that typically occurs in the spring and early summer. With the U.S. particularly dependent at that time of year on light sweet crudes, that relative strength is most pronounced for grades such as the U.S. marker crude, West Texas Intermediate (WTI). In years when mid-continent crude stocks are low, or pipeline capacity is tight, the result can be price spikes and disconnects with world prices.

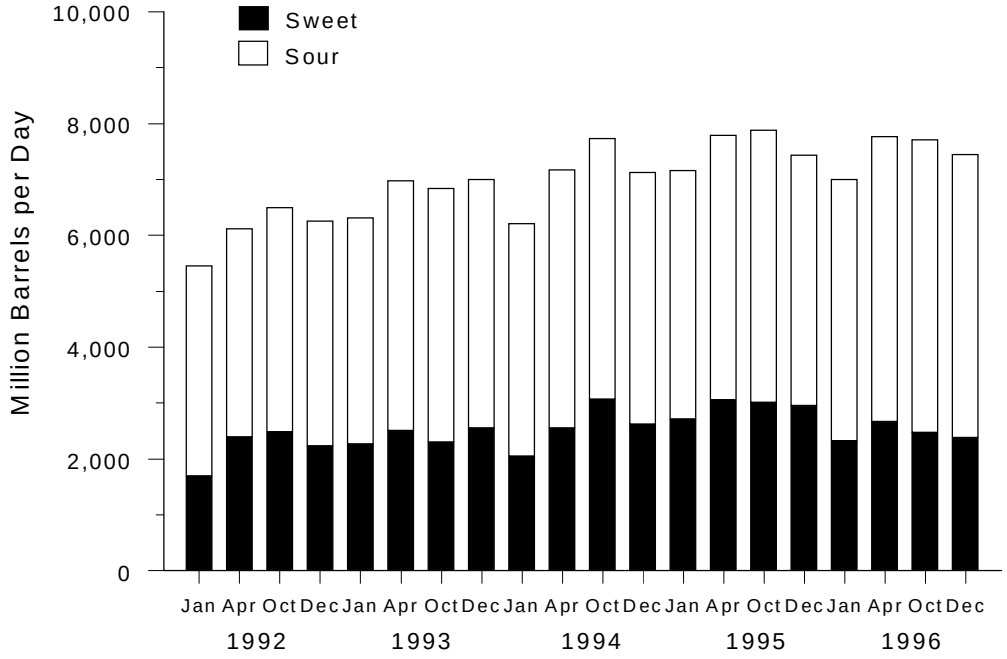
Crude Oil Exports

Crude oil exports play a minor role in the U.S. crude oil balance, averaging just 100-200 thousand barrels per day since 1985 (Figure 64), because they have essentially been banned for most grades most of the time. However, even if there were no restrictions at all, the status of the U.S. as the world's largest net importer of crude would ensure that exports would remain small in almost all circumstances.

Export Ban Diverted Alaskan Oil to East of the Rockies and the Virgin Islands

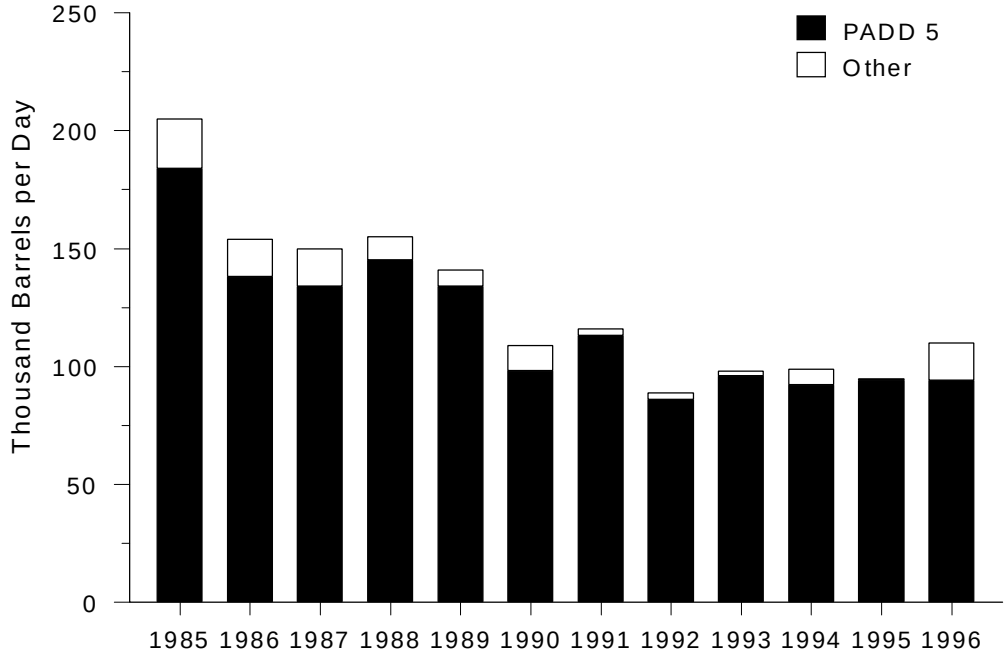
This would not entirely have been the case when Alaskan North Slope (ANS) production was in its prime. Its substantial West Coast surplus would have moved primarily to Asia if normal supply economics had applied. Instead, an ANS-specific export ban meant effectively that it could only

Figure 63. Quarterly Volumes of U.S. Crude Oil Imports by Sulfur Content



Source: Energy Information Administration, Form EIA-814 data.

Figure 64. U.S. Crude Oil Exports by Exporting Region, 1985-1996



Sources: Energy Information Administration (EIA), *Petroleum Supply Monthly* and EIA, *Petroleum Supply Annual* (various issues).

be moved either east of the Rockies or, under a special exemption for U.S. territories and possessions, to the Virgin Islands or Puerto Rico — with both the latter still counting as exports in the statistics. None of these destinations would have been natural choices in a free market because of the significant freight costs attached to such moves due to either Jones Act restrictions or sheer distance. For example, the voyage from Valdez, Alaska to the Virgin Islands is the longest regular voyage in the world oil market, covering around 15,000 (nautical) miles and taking up to 50 days. But all these markets, particularly the Virgin Islands, helped at times to increase the producers' total net revenue relative to the alternatives of either swamping the West Coast or limiting ANS production.

It was therefore ANS flows to the Virgin Islands that accounted for the overwhelming majority of U.S. crude oil exports over the last decade, which is also why almost all exports flowed out of the West Coast. And it was primarily the decline in both ANS and Californian production, together with the increased flexibility of West Coast refiners to run greater volumes of these poorer quality crudes, that led to the halving of exports in the second half of the 1980's.

With the Ban Lifted, Alaskan Crude Is Moving to Asia

After nearly twenty years of production, and with volumes only 70 percent of peak flows, a Bill lifting the ban on ANS exports was finally passed in November 1995 and implemented in July 1996. On the surface, nothing appears to have changed, with ANS exports in 1996 equal to those in 1995. But the absence of any increase is due to the continuing decline in ANS production, which was down another 90 thousand barrels per day in 1996. The new reality is being reflected in the flows. Waterborne, and almost all pipeline, flows of ANS to the Gulf Coast have ceased; exports to the Virgin Islands have plunged to 10 thousand barrels per day in the last five months from over 90 thousand barrels per day in the previous three and a half years; and significant parcels of ANS have moved to four Asian countries, although these movements have been intermittent except for the 50 thousand barrels per day to Korea.

The ongoing decline in the West Coast surplus of ANS crude was gradually eroding ANS in-transit stocks of this crude. Lifting the export ban has caused a further, sharp reduction since ANS in transit overseas to destinations other than the Virgin Islands is not included in this calculation. This contributed to the exceptionally low crude stock levels seen in the U.S. in 1996 (see Chapter 5).

Non-ANS Exports Are Minor

The non-ANS component of U.S. exports has included intermittent, minor flows from other special case sources on the West Coast, such as Cook Inlet production from Alaskan state waters and, since 1991, Californian heavy crude. There has also usually been some U.S. crude moving north by pipeline or truck into eastern Canada. The very modest baseload comes from production near the border, augmented, when the economics are favorable, by more widely traded crudes like West Texas Intermediate. (Note that crude oil in transit through the U.S. for Canada, such as via the Portland pipeline to Montreal, does not show up in these export statistics.)

U.S. Crude Exports Will Always Be Modest

As Asian refiners adjust to ANS crude, become more comfortable with U.S. tanker legislation, and more market oriented as their markets become more open, then crude oil exports from the U.S. could temporarily grow modestly again. But U.S. exports will never be a significant force in world crude markets.